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INVESTMENT REQUIREMENTS AND THE PARTICIPATION OF KOREAN AND TAIWANESE FIRMS IN TECHNOLOGY-INTENSIVE INDUSTRIES

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ABSTRACT

Investment Requirements and the Participation of Korean and Taiwanese Firms in Technology-Intensive Industries

The focus of the paper is the hypothesis that high investment costs associated with technology-intensive activities preclude entry by relatively small firms, leaving national Taiwanese firms at a disadvantage in technology-intensive sectors relative to Korea. The paper explores the extent to which the hypothesis helps account for the relative performance of Korea and Taiwan in five product categories within the information industry. The five products targeted in field research were the assembly of personal computers (PCs); the manufacture of two peripherals for PCs, keyboards and hard disk drives (HDDs); and the fabrication of two components used in disk drives, media and precision motors. The findings from the field research, and thus the basis for the conclusion summarized below, are laid out in detail in the paper.

For three of the five products -- the manufacture of media and precision motors, and the assembly of HDDs -- the initial investment costs for entry at efficient size were indeed quite substantial, and the character of the production process afforded little opportunity for entry by firms unwilling to meet these costs. Even so, there was no evidence that these investment costs inhibited entry by Taiwanese firms. For the remaining two products-- the manufacture of keyboards and of PCs -- there was substantial variation in the size of firms at entry, with Taiwanese firms substantially smaller at entry than their Korean counterparts; however, the smaller size of Taiwanese firms at entry for these two products left them in no way disadvantaged relative to the Korean companies.

For investments in potentially profitable technology-intensive activities where up-front costs are in the $10 million to $20 million range, access to finance does not represent a significant obstacle to entry on the part of Taiwanese firms, although Korea's giant conglomerates might enjoy an advantage over Taiwanese firms in high-tech activities involving substantially larger investments than were required for the products that were the focus of the present research effort. The advantages of size are not, however, ubiquitous. There is a whole range of technology-intensive activities to which the structure of Taiwanese industry, with its preponderance of dynamic small firms appears to be exceedingly well adapted.

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Investment Requirements and the Participation of Korean and Taiwanese Firms in Technology-Intensive Industries

by

Brian Levy and Wen-Jeng Kuo

This paper is one of two companion pieces[1] that report and interpret the results of field interviews conducted in May and June 1987 with manufacturers in the information industry in Korea and Taiwan. The goal of the field research was to explore the impacts of the very different industrial structures of the two countries on the prospects for successful promotion of the information and other frontier industries in which technology- and innovation-intensive activities play a major role.

In Korea, a small number of conglomerate giants tower over the industrial landscape. In Taiwan, there is a proliferation of small and medium enterprises; the largest industrial enterprises on that island occupy nothing like the relative position of their Korean counterparts. In 1981, establishments with 500 or more workers accounted for 58 percent of gross manufacturing output in Korea, but only 47 percent in Taiwan.[2] Moreover, Korean factories tend to not be owned by individuals, but disproportionately under the control of giant conglomerates, the Chae'bol. The five largest Chae'bol accounted for 22.3 percent of the total value of 1983 shipments by the Korean manufacturing

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1. The second piece, entitled "The Strategic Orientations of Firms and the Performance of Korea and Taiwan in Frontier Industries: Lessons from Comparative Case STudies of Keyboard and Personal Computer Assembly" explores differences in the characteristic strategies of Korean and Taiwanese firms in technology-intensive industries

2 Republic of Korea, Economic Planning Board, Mining and Manufacturing Survey, 1981; and Republic of China, Directorate General of Budget, Accounting and Statistics, The Report on Industrial and Commercial Census, Taiwan-Fukien Area, 1981

sector;[3] the equivalent share for the five largest private Taiwanese groups--none of whom are anything like the size of their Korean counterparts--amounted to only 4.2 percent.[4]

The focus of the present paper is the hypothesis that high investment costs associated with technology-intensive activities preclude entry by relatively small firms, leaving national Taiwanese firms at a disadvantage in technology-intensive sectors relative to Korea. Does the hypothesis help account for the relative performance of Korea and Taiwan in the five product categories that were the target of study? The paper reports on patterns of entry and subsequent performance by seventeen Korean and Taiwanese manufacturers in the five categories. As will be clear, the evidence leads us to reject the hypothesis.

Evidence from Five Products

There are plausible grounds for an a priori expectation that Korea's industrial structure imparts to that country an advantage over Taiwan in technology-intensive activities. The mastery by firms of complex technology takes both time and resources. Time for experiment, learning and adjustment prior to the initiation of commercial production. And resources to cover the costs of R&D and of any licensing that may be needed, the costs of investment in plant and equipment, and the costs of the inevitable losses associated with the start-up of commercial production; these last may include initially high

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[3] For overviews of the role of the Chae-bol, see Lee (1986) and Jones (1980). The estimate in the text is from Lee, p. 239.

[4] In 1985, gross sales of the largest Korean conglomerate amounted to $13 billion, and of the largest Taiwanese group $1 billion. The estimate of the share of gross manufacturing output accounted for by the five largest Taiwanese groups is calculated from Top 500, China Credit Information Service, 1986 and Republic of China, Ministry of Economic Affairs, Department of Statistics, Report on Industrial and Commercial Survey, Taiwan Area 1986.

costs as the firm learns-by-doing to improve productivity, excess capacity (costly insofar as initial fixed investments are large) prior to the firm winning the confidence of initially sceptical buyers, and purposive discount pricing as the firm endeavors to win market share from established producers. It is plausible to hypothesize that the costs associated with technology-intensive activities preclude entry by relatively small firms that (given only moderately imperfect financial markets) are likely to lack access to the financing needed for investment in activities involving long lead times, high fixed costs and uncertain outcomes. The proposition follows -- and has been drawn by at least one researcher[5] -- that the disproportionate role of smaller firms in Taiwan is likely to place that country at a disadvantage in technology-intensive activities relative to Korea, where resources are concentrated in the hands of a few, massive Chae'bol.

The five products targeted in our field research were the assembly of personal computers (PCs); the manufacture of two peripherals for PCs, keyboards and hard disk drives (HDDs); and the fabrication of two components used in disk drives, media and precision motors. Table 1 breaks down the sample of firms interviewed in the course of field research by country and product category. There was some variation in the completeness of our coverage of firms in each product category. Only one firm was engaged in the production of media, and one in the manufacture of precision motors, in each country; so for those two categories our coverage was exhaustive. The four assemblers of HDDs that we interviewed accounted for the overwhelming bulk of HDDs assembled in the two

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[5] See Mody (1985)

Table 1: A Disaggregation of the Field Sample by Product Category

Product	Korea	Taiwan
Keyboard	2	3
PC Assembly	2	2
HDD Assembly	2	2
Media Manufacture	1	1
Precision Motor Manufacture	1	1
Total Number of Firms	8	9

countries.[6] The two Korean keyboard interviewees represented the dominant, and only other significant, suppliers of keyboards from that nation; the Taiwanese keyboard firms comprised three of the seven leading exporters of keyboards from that island. The four PC interviewees represent only a small sample from an industry with a relatively large number of participants; moreover, the sample is one that is (by intent) skewed towards leading PC suppliers in the two countries.[7]

As will be described below, for three of the five products -- the manufacture of media and precision motors, and the assembly of HDDs -- the initial investment costs for entry at efficient size were indeed quite substantial, and the character of the production process afforded little opportunity for entry by firms unwilling to meet these costs. Even so, there was no evidence that these investment costs inhibited entry by Taiwanese firms. For the remaining two products -- the manufacture of keyboards and of PCs -- there was substantial variation in the size of firms at entry, with Taiwanese firms substantially smaller at entry than their Korean counterparts. However, as is noted below and is explored in detail in the companion paper, the smaller size of Taiwanese firms at entry left them in no way disadvantaged relative to the Korean companies.

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[6] Along with the four interviewees, two further Korean firms had made some preliminary forays into HDD assembly. And four multinational firms had expressed interest in establishing assembly subsidiaries (two in each country) with varying levels of actual commitment.

[7] The small size of the sample was unavoidable given our limited resources and the necessity of making the comparison between Korea and Taiwan across a number of product categories. We decided to focus on leading firms in part because we felt they would provide a better perspective on the overall structure of the industry than more minor players, and in part because -- given the importance in the present analysis of the role of strategy -- they offered richer information as to the trajectories of expansion of significant players in the industry.

Entry and performance with substantial investment costs. Table 2 summarizes available estimates of the investment costs required for initiating production in the three categories for which initial investment costs were substantial in both countries: the estimates for media production ranged between $11 million and $20 million; for HDD assembly, the most comprehensive esimate amounted to $11 million; investment costs prior to the start-up of production of precision motors was put at $5 million. These initial investment costs notwithstanding, there was no evidence that Taiwan lagged behind Korea. On the contrary, for two of the three categories the edge in performance lay with the Taiwanese firms.

To begin with media,[8] Taiwan's sole media company was begun in 1983 in California, USA by a Chinese American (a member of a wealthy Chinese family with long-standing roots in Taiwan) with extensive experience in the US computer industry. Production in the company's Taiwan facility -- operated by the brother of the founder, a long-term Taiwanese resident -- began in 1986. At the time of our interview, the company was producing at full capacity, 60,000 media per month, and was in the process of acquiring equipment to double capacity to 120,000 media monthly within the following two months, with a further doubling -- to 240,000 monthly -- scheduled for 1988.

Korea's sole media facility also was founded in 1983. However, its efforts at commercial production of media have thus far proven less than wholly successful: it was only in April 1987 that the company was able to conclude its

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[8] Media is another name for the hard disks for storing information that are sealed into hard disk drives for PCs. The production of media involves two basic steps: the precision machining of an aluminum plate to a mirror-like surface; and the coating of that plate with a series of nickel, cobalt, chrome and carbon compounds. The process is very technology-intensive, involving as it does complex scientific skills embodied in chemical engineering and electronics engineering, as well as high-precision mechanical engineering.

Table 2: Some Estimates of Initial Investment and Start-up Costs[1/] for Three Technology-Intensive Products

	Korea	Taiwan
Media	$11 million	$20 million
HDD Assembly	$ 4 million[2/]	$10 million
Precision Motors	- [3/]	$ 5 million

Sources: Estimates provided by firms in the course of field interviews

Notes : 1/ Firms were asked to include investment costs, costs of R&D, and losses associated with start-up.

2/ Estimate excludes costs incurred in the course of initial R&D and in the course of prior experience with assembly of floppy disk drives.

3/ No estimate was provided by the Korean manufacturer

first sales of media.[9] Indeed, in 1986, when it had become apparent that the commercialization of media was not yet at hand, the Korean firm entered into a second line of business, HDD head assembly.[10] By mid-1987 head assembly was bringing in $2 million monthly; prospects for 1988 and beyond were that head assembly would account for 70 percent of the company's revenues, with the manufacture of media now a secondary activity.

The Taiwanese lead in precision motors -- stepper and spindle motors for floppy disk drives[11] -- is at least as substantial. The only manufacturer for sale of these motors in Taiwan at the time of our interviews commenced operations in July 1984 as a joint venture, with 60 percent of the equity in the hands of a wealthy Taiwanese businessman, and 40 percent controlled by an established Japanese manufacturer of precision motors. By early 1987 it was operating at full capacity, producing 60,000 spindle and 45,000 stepper motors each month. By the end of 1987 its capacity (and production) of spindle motors will rise to 90,000 monthly; and in 1988 the company will commence production

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[9] The primary reason for the difference in performance between the Korean and Taiwanese companies lay in their choice of technology: whereas the Taiwanese company concentrated its efforts on mastery of a conventional technique of long standing for coating chemically the surface of the media (and took over in 1984 an existing USA media company as a way of acquiring the technology), the Korean firm attempted to master -- with only minor consulting services from Koreans employed in the industry in the USA -- an innovative process that, given mastery, held out the prospect of a higher quality, lower cost product than could be manufactured via the conventional technique.

[10] HDD head assembly is a straightforward, if precision, operation (lower-tech than media manufacture) involving the winding under a microscope of hair-thin wires that connect a ferrite head to an aluminum flexure.

[11] No firms in either country had begun to manufacture motors for hard disk drives. Spindle motors rotate at rapid speed the floppy disks that contain information; stepping motors glide the magnetic head that reads the information rapidly back and forth above the surface of the floppy disk. High levels of precision engineering are necessary to ensure that the motor maintains a stable speed at very high temperatures, and to minimize motor vibration.

of precision motors for video tape recorders.

The Korean manufacturer that we interviewed -- a division of a company that is part of one of Korea's largest conglomerates --is also the only manufacturer for sale of stepper and spindle motors in that country. Since 1983, 36 Korean engineers have been engaged full-time in the effort to develop stepper and spindle motors for floppy disk drives.[12] In 1985 the company began to gear up for mass production with lines capable of producing 10,000 units per month of each of the two motors. However, even in early 1987, production remained well below capacity;[13] the company expects to have these motors on the market sometime in 1988.

The evidence as to which country has the edge in performance is somewhat more ambiguous for the assembly of HDDs, an activity in which no firm in either country has yet secured a strong market position. On the basis of evidence gathered in the course of our field interviews as to the cumulative value of sales thus far, we conclude tentatively that a Korean firm appears marginally ahead in the early running.

All four HDD firms interviewed had ready access to the requisite investment finance. The two Korean operations both were attached to conglomerates, as was

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[12] According to our interviewees, at the time the company embarked on its project no Japanese firms were willing to provide technical assistance.It is not clear whether efforts were made to conclude a joint venture agreement of the type negotiated by the Taiwanese firm.

[13] Notwithstanding its difficulties with motors for floppy disk drives, the Korean company is moving ahead with efforts to develop (even higher precision) stepper and spindle motors for HDDs, this time with the aid of technical assistance agreement concluded in 1986 with a US firm. The company expects to have these motors on the market sometime in 1988. Interviewees in Taiwan averred that it would take until 1989 before they felt they would have sufficient experience to master production of motors for HDDs.

one of the Taiwanese;[14] the second Taiwanese HDD venture was an independent firm established by the son of one of Taiwan's most powerful businessmen. Two of the firms -- one Korean and one Taiwanese -- commenced their efforts in 1982: in that year, the Korean firm assigned five engineers to work on the design of floppy disk drives in the groups R&D facility; and the Taiwanese firm set up a new R&D facility in Silicon Valley, California, charged with the objective of developing an HDD for commercial production. Efforts of the remaining two firms commenced in 1986 -- in the form of a joint venture with a USA company on the part of the Korean operation, and with the establishment of clean-room facilities for HDD assembly[15] by its Taiwanese counterpart.

At the time of our interviews, none of the four firms were producing at levels commensurate with their ambitions. Production by the two Taiwanese firms amounted to 3-6,000 and 5-8,000 HDDs per month; their respective capacities were 20,000 and 50,000 units monthly. Nonetheless, both[16] Taiwanese firms were

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[14] One of the Korean operations is a division in a company that was started up when in 1983 the President of a $13 billion (in sales revenue) Korean group determined that the time had come for his conglomerate to establish a presence in the electronics industry. The second was the flagship company of a medium-sized (by Korean standards) group; total 1986 group sales amounted to $160 million. The Taiwanese operation was attached to one of that island's three largest conglomerates, which had total 1986 sales of $500 million (Kuo? accurate?)

[15] HDDs must be assembled manually by skilled workers in carefully sealed, dust-free clean rooms. As its name implies the HDD is a mechanical device whose function is to locate specific information on the media in response to a signal from the PC user: one motor -- the spindle motor -- rotates the media at a speed of 3,600 rotations per minute; a second motor -- the stepping motor-- glides the magnetic head that reads the information rapidly back and forth, 1/10,000 of an inch above the media surface. The high density with which information is stored on media, the very rapid retrieval time, and the need for reliable, accurate performance imply that the HDD is a high-precision mechanism, and thus that its assembly is a technology-intensive task.

[16] For at least one of these firms (the earlier entrant), the strategy of in-house design reflected a larger commitment to move to the cutting edge of technology by taking advantage of Chinese (in the USA as well as Taiwan) skills

pushing ahead with efforts to design the next generation HDD, and be in a position to play a leading role when the market catches up. Production volumes in the large, new factory building of one of the two Korean operations (its ties with its erstwhile joint venture severed, and production for new orders not yet underway) were all but nonexistent; however, the firm apparently was on the brink of announcing an agreement to supply a US firm with 8,000 HDDs per month, rising over time to 25,000 monthly. Only the remaining Korean firm gave evidence of substantial activity, with one longstanding contract for 5,000 HDDs per month, and a second contract (production of which was starting up at the time of our interview) for a further 10,000 units monthly. The ambition of this last firm was to produce 30,000 HDDs monthly by the end of 1988.[17]

Entry at divergent sizes. The hypothesis of a putative shortfall in Taiwan of firms willing to make substantial up-front investments has no power to explain variations in the performance of Korean and Taiwanese firms in the manufacture of media and precision motors and in the assembly of HDDs. The hypothesis has equally little explanatory power in accounting for performance in the supply of keyboards or complete PCs. But whereas for the first three product categories it was the demonstrated ability of Taiwanese firms to raise the requisite finance that led us to reject the hypothesis, for the remaining two categories, it is the ability of Taiwanese firms to enter at small-scale

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and design capabilities.

[17] At which time HDD revenues were projected to amount to $100 million, 50 percent of total projected revenues for the group. The initial contract was for HDDs of a relatively idiosyncratic design, which offered few opportunities for additional market penetration; the more recent contract is for HDDs of more standard design. Along with its HDD production, the firm continues to supply 5,000 FDDs monthly to the domestic market.

and expand rapidly thereafter that offsets the impact of any shortfall on that island of firms willing to make substantial up-front investments.

Korean and Taiwanese suppliers of keyboards and of PCs differed radically from one another in their sizes at entry. In their initial year of operation the five Taiwanese keyboard and PC suppliers that we interviewed all had fewer than twenty employees, and well below $1 million in sales revenues; all five firms were begun by young engineers, recently graduated from university, with at most a few years experience in other companies. By contrast, the two manufacturers of keyboards in Korea (as noted earlier, the dominant and the only other manufacturer of keyboards in the country) were both established on a relatively large scale as 50:50 joint ventures with Japanese interests; the joint ventures were conduits of Japanese switch technology to the burgeoning Korean market for components of manufactured electronics products, with keyboards and keyswitches only two lines among many. And both Korean suppliers of PCs were started up expressly as high-volume producers of PCs for the USA market; both firms commenced production with contracts already in hand to ship to the USA 10,000 PCs per month, implying a corresponding gross sales revenue for the first year of production in excess of $40 million.

The reasons for, and the divergent strategies associated with, these diverse sizes at entry are the subject of the companion paper. What is relevant here is that the smaller size at entry of the Taiwanese firms did not result in poorer performance in Taiwan than in Korea. For one thing, none of the five Taiwanese firms in our field sample have remained small. Projected 1987 revenues of the five firms amounted to $9 million, $20 million, $35 million, $120 milllon and over $200 million. Between 1982 and 1986 the annual growth rate in sales of the most conservative of the firms ranged between 50 and 100 percent.

More generally, there is no evidence that Taiwanese industry lags behind that of Korea in the supply of either PCs or keyboards. As late as 1983, neither Korea nor Taiwan was a significant exporter of keyboards. Yet, as Table 3A reveals, as of 1986/7 Taiwan commands four times as much industry capacity, six times the value of exports, seven times the number of firms with sales of 30,000 or more keyboards monthly, and nine times the number of industry participants as does Korea. The comparative data on relative performance in the supply of PCs are more ambiguous. As is illustrated in Table 3B, the value of PC exports from the two countries in 1986 was almost identical, with Korea's expansion especially rapid after an initial lag. What these data do not reveal, however, is the relative sophistication of the two industries: suppliers of PCs can run the gamut from low-technology firms that undertake the relatively simple process of assembling the components that go into a personal computer, to firms with highly qualified R&D teams with the capacity to develop in-house their own circuit designs for PCs. One indicator of the sophistication of the PC industry in the two countries is the share of 'own-brand' PCs in total exports.[18] At least on the basis of this indicator, the data in Table 3 suggest that it is the Taiwanese industry that is ahead.

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[18] In principle, the best indicator would be data from case studies of the type summarized in this study. However, for reasons noted earlier, our sample (evidence from which is described in more detail below) is too small and biased to permit anything more than speculative comparisons. The indicator used in the text is particularly problematic insofar as the share of non-branded exports is likely to be affected by the characteristics of the marketing networks of the two countries (an issue that will be analyzed in more depth later in the paper), as well as by the degree to which firms in the two countries have the design competence to market for export their own brand of PCs.

Table 3: Selected Statistics on the Keyboard and PC Manufacturing Industries in Korea and Taiwan

	Korea	Taiwan
A: Keyboards		
Value of Exports, 1986	$5-$20 million	$70-$90 million
Number of Assemblers with sales of 30,000 or more units monthly (March, 1987)	1	7
Total Number of assemblers	5	44
B: PCs		
Annual Export Values		
1983	$ 36 million	$ 12 million
1984	84	153
1985	159	240
1986	404	393
Exports of 'own-brand' as % total PC exports	16%[1/]	28%[1/]
Number of PC Assemblers	38	119[2/]

Sources: Republic of China, Institute for the Information Industries, A Comparative Analysis of the Information Industry in Korea and Taiwan (Taipei: May, 1987) (in Chinese); Taiwan Electronic Appliance Manufacturers Association, Annual Directory of Manufacturers 1986/7; Electronic Industries Association of Korea, Annual Directory of the Information Industry 1987; and data supplied during interviews with association officials and with firms.

Notes : 1/ The other classes of exports are exports by subsidiaries of multinational firms (50 percent of the total in Taiwan, and 40 percent in Korea), and non-branded OEM exports for large foreign buyers.

2/ 43 of the 119 firms listed their assets as below $100,000; at least some of these firms are most likely traders rather than assemblers.

The Fallacy of Gigantism

The evidence presented in this paper suggests that the larger size of Korean firms has not translated into a clear advantage in any of the five products that were the subject of our field research. One implication of the research (and also of numerous informal conversations as to the availability of venture capital in Taiwan) is that, for investments in potentially profitable technology-intensive activities where up-front costs are in the $10 million to $20 million range, access to finance does not represent a significant obstacle to entry on the part of Taiwanese firms. A second implication, explored in the companion paper, is that in sectors that permit variations in the sizes at entry of efficient firms, firms that enter small can nonetheless expand rapidly to become formidable competitors.

This is not to say that the giant size of the Korean conglomerates confers no advantages. For one thing, this giant size can permit technology-intensive activities across a whole variety of components that, taken together, comprise a complete system; however, our field research uncovered no evidence of integrated, system-wide efforts at technological development in the personal computer industry in either country. For another thing, Korean Chae'bol might enjoy an advantage over Taiwanese firms in high-tech activities involving substantially larger investments[19] than were required for the products that were the focus of our field research. Thus Mody (1985) bases his conclusion that the large size of their conglomerates has conferred an advantage for Korea over Taiwan largely on a comparison of the semiconductor industry in the two

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[19] And, of course, for activities that though not especially intensive in their technological requirements require major up-front investments of capital (shipbuilding, for example).

countries, a sector where the level of production in Korea (1986 sales amounted to $1.4 billion) has pulled far ahead of the level in Taiwan (1986 sales of $610 million).[20] Underlying these differences in sales were enormous differences in investment levels: between 1984 and 1986 Korean firms invested $1.4 billion, and Taiwanese $300 million;[21] as of mid-1987 the leading Korean semiconductor supplier (Samsung Semiconductor and Telecommunications) had itself invested over $500 million in semiconductor facilities.[22]

What our research does suggest is that these advantages of size are not ubiquitous. On the contrary, there are likely to be a whole range of technology-intensive activities to which the structure of Taiwanese industry, with its preponderance of dynamic small firms, is exceedingly well-adapted.

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[20] Republic of China, Institute for the Information Industry, A Comparison of the Information Industries of Korea and Taiwan (Taipei: May 1987) p. 25

[21] Mody (1985) p. 27; the Korean data are projections as of 1984; the Taiwanese figure was a 1984 projection for the subsequent three to five year period.

[22] It remains to be seen whether Korea's large investment in semiconductors pays off. As of mid-1987 the Koreans had consistently lagged behind the industry leaders, bringing products on stream only once they had already become industry standards, their prices already driven down to cutthroat levels. At present, the three major Korean semiconductor makers (with the support of government) are collaborating on development of the next generation -- 4M DRAM -- of semiconductors. For data and further analysis, see "Samsung Semiconductor and Telecommunications: The Worst is Over?" Business Korea, June 1987 pp. 36-38; "W120.5 billion ($150 million) Set Aside for VLSI Chip Development", Korea Trade and Business, May 1986 p. 7; "Semiconductors: What's Shortcircuiting the Industry?" Korea Business World, September 1985, p. 16-17; "Chips on the Block" Business Korea, May 1985, pp. 28-30.

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